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Superconducting photocathode quantum efficiency enhancement with UV plasmonics

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A surface modification technique is described that significantly enhances the photoelectric quantum efficiency (QE) of Nb at 248 nm by more than two orders of magnitude, thereby making this material suitable potentially as a cathode for superconducting radiofrequency (SRF) photoinjectors. The approach uses ultra-thin-film metallic coatings that exploit proximity coupled superconductivity, as well as plasmonic resonances in the deep UV, to enhance QE while at the same time allowing exposure of the Nb cathode to air. The first step is the in-situ deposition of a 10 nm layer of Mg onto a clean Nb surface prepared by a high temperature UHV anneal. Earlier proximity effect studies of similarly processed Nb/Mg bilayers reveal the superconducting gap of Nb on the surface indicating the induced superconductivity in the Mg layer should maintain the low RF losses of Nb. Deposition of ultra-thin islands of In (4 nm thickness) on top of air exposed samples (Nb/Mg/Mg-oxide) leads to reproducible overall enhancements of QE by a factor of greater than 400. This strong enhancement is attributed to the deep UV plasmon resonances of the In islands observed in the optical reflectance of the coated Nb sample and found in COMSOL simulations. This proof-of-principle experiment opens the door to lithographically tailored surface plasmonic nano structures to create fully superconducting photocathodes based on Nb, or other higher Tc superconductors, that are robust in air and have acceptable QE values in the UV.

Presenter: Dr SPENTZOURIS, Linda (Illinois Tech (IIT))

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